APPLICATION GUIDE FOR OCCUPANT SENSORS

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INTRODUCTION

Occupant (or occupancy) sensors have been used to control lights for a number of years, yet problems with misapplication and improper installation still exist. Occupant sensors can be viable energy savers if the correct product selection is made. Proper design, installation and follow-up adjustment are essential to achieving an effective lighting sensor program. If the sensor design and placement are well thought out, it is much less likely that complaints will occur, thus also less likely that the sensors will be disabled.

TYPICAL USES

Occupant sensors (O.S.) have been used primarily to control incandescent lighting in residences and fluorescent lighting in commercial buildings. Some O.S. are available to control high intensity discharge (HID) lighting and heating, ventilating and air conditioning (HVAC) systems. The advantages of incorporating occupant sensors into a lighting system include:

- saving energy
- minimizing heat output from lighting, putting less load on the HVAC system
- prolonging the life of lamps and ballasts

Representative energy savings are described in the table below.

Type of Room	Energy Savings
Private Office	13-50%
Open Plan Office	20-28%
Classroom	40-46%
Conference Room	22-65%
Rest Room	30-90%
Corridors	30-80%
Storage Area/Closet	45-80%

Source: Advanced Lighting Guidelines, U.S. EPA

O.S. are viable energy savers primarily where human occupancy is intermittent. In large open plan office area where people are expected to be moving about continuously throughout the day, judicious use of occupant sensors is paramount. Applying O.S. in classrooms, offices, restrooms, warehouses, hangars, and equipment and storage rooms will save energy by turning off lights when no human presence is detected. This paper addresses the available technologies and selection factors for occupant sensors in abbreviated form. More detailed O.S. application guidance is included in the references listed at the end of this paper.

SENSOR TECHNOLOGIES

The two primary technologies used to detect occupancy are ultrasonic and passive infrared (PIR) employed singly or with each other in a dual-technology sensor. Other dual-technology sensors are also available that combine PIR with active sound detection.

ULTRASONIC SENSORS

Emit ultrasonic radiation (high-frequency sound) to sense occupants in an area. Frequency range of operation is between 20 and 28 kHz. They are most sensitive to motion toward and away from sensor. An ultrasonic sensor is volumetric, meaning it floods the area within its coverage pattern. This allows it to detect motion behind partitions and around obstructions. Any moving object within its coverage area will disturb the sound wave pattern, creating a Doppler shift and altering the signal returning to the sensor. False activation may occur from vibration, air movement, high sound levels, and audible sounds having ultrasonic components. Ultrasonic sensors have sensitivity adjustments to minimize environmental effects. Reducing sensitivity will also reduce the coverage area. If ultrasonic sensors are mounted close to each other, they must operate at different frequencies to avoid interfering with each other.

PASSIVE INFRARED SENSORS

PIR O.S. are sensitive to body heat and work best when the person is moving across the sensor pattern. PIR sensors are available to generate specific patterns of coverage: fan shaped pattern for smaller areas (private offices), 360 degree pattern for large areas (open plan offices), and long narrow pattern for areas such as hallways. Lenses may also be field modified to mask part of its sensor’s viewing area to avoid a heat generating device or to avoid an area having movement that is not intended to trigger the

sensor. PIR sensors have some dead spots primarily at long distances from the sensor. Because it is sensitive to body heat, the infrared O.S. is also sensitive to any rapid fluctuations in temperature within its field of view. Be sure no rapidly changing heat sources are in the area where the infrared O.S. is to be used. Solar heating of glass and metal surfaces can cause unwanted sensor activation. The sensor can be blinded by the sun shining directly on it. For optimum effectiveness, use PIR sensors in areas having no obstructions to occupant movement, since it is a line-of-sight device.

DUAL-TECHNOLOGY SENSORS

Combine infrared and ultrasonic technologies into a single housing. Dual-technology sensors are good for areas where a single technology O.S. has difficulty detecting human movement and where one or the other technology is prone to false activation. Although ultrasonic and PIR technologies remain predominant for occupant sensing, a relatively new dual technology sensor is now on the market. This device combines PIR with an active listening system. After the PIR detects someone entering the area, the microphonics take over. Lighting remains on as long as sound is detected, even though the PIR device is not triggered. This sensor’s applications include office spaces with cubicles, conference rooms and large restrooms and shower areas.

CAUTION AGAINST USE OF INTRUSION DETECTION SENSORS

While intrusion detection system (IDS) sensors utilize the same technologies as lighting control sensors, IDS sensors are normally not compatible with lighting control systems. IDS sensors are typically not rated for the load switching that accompanies lighting circuit activation. Even though microwave motion sensors exist for security system applications, do not use them for occupant detection since microwaves pass through most building materials and will detect movement beyond the desired coverage area. For best results, employ O.S. that are designed specifically for lighting (or HVAC) control.

MOUNTING METHODS

Sensors are designed for mounting as light switch replacements, for ceiling mounting, or for wall mounting. Portable plugstrip units are available, as are units for controlling systems furniture lighting.

LIGHT SWITCH REPLACEMENT

Direct replacement of a wall mounted light switch with a PIR O.S. will likely only be acceptable in smaller rooms where no partitions obstruct the sensor's view of the room's occupants' movements. These wall switch replacement units typically are rated to control only the lighting fixtures connected to the switch. To avoid false activation, manual turn-on, automatic turn-off is recommended. In private offices, this would preclude activation by someone just dropping off mail, plans, etc. Manual turn-on is also beneficial where available daylight allows the electrical lighting system to remain off for several hours at a time.

CEILING MOUNT

These units are available in infrared, ultrasonic, and dual-technology. Use for large area coverage and rooms with partitions and other obstructions. Ceiling mounted O.S. connect to lighting system through transformers and relays to operate a large number of lighting fixtures on multiple circuits.

WALL MOUNT

These units should be mounted high enough up on the wall to ensure desired coverage in the presence of systems furniture and file cabinets. Be sure the sun does not shine on them and be sure they are not focused on objects that can change temperature rapidly.

SYSTEMS FURNITURE AND PLUGSTRIP UNITS

More and more administration buildings are being designed with lower general lighting levels and relying on individual office/cubicle lighting. Typically, general illumination levels are now 3 lux (30 fc) versus 5 lux (50 fc). Individual office/cubicle lighting supplements general illumination with the amount of light needed by the occupant. Some systems furniture suppliers are integrating occupant sensors into their offerings. Plugstrip occupant sensors can be employed in existing office setups or with new systems furniture that does not incorporate O.S. into their product line.

PROPER O.S. LOCATION

Improper location is the most significant factor in O.S. misapplication. Locate sensor so that it will not detect movement

outside the desired coverage area through an open doorway. In many cases, wall switch replacement O.S. are ineffective because the existing wall switch location is behind a partition or on the wrong side of a wall, limiting motion detection to a very small part of the desired coverage area.

COMPATIBILITY

Be sure O.S. is designed to control the type of lighting system you have specified for new projects or for the existing lighting system in a renovation project. Not all sensors will work with fluorescent loads having standard or electronic ballasts or with compact fluorescent lamps.

RAPID-START VS INSTANT START BALLASTS

When extensive use of O.S. is planned for a project, the designer should perform cost analysis on the use of rapid-start versus instant-start ballasts. Rapid-start ballasts use more energy due to lamp cathode heating. For best results, use O.S. with rapid-start fluorescent ballasts, particularly with short “off” times (five minutes). It is not recommended to use O.S. with instant-start fluorescent ballasts, unless “off” time is very long (30 minutes, minimum), since lamp life will be shortened. Note that dimming electronic ballasts use rapid-start circuits. Some manufacturers indicate that their fluorescent lamps, electronic ballasts and occupant sensors are “system rated.” Check the compatibility of components with each other before specifying.

COMPACT FLUORESCENT LAMPS

Compact fluorescent lamps should have a minimum 3-hour “on” time to prevent significant loss of lamp life.

HID LIGHTING

Before specifying O.S. to control High Intensity Discharge (HID) lighting, check with O.S. manufacturer and HID lamp and ballast manufacturer for application data.

IN-RUSH CURRENT

In-rush current is the momentary surge that occurs when an electrical device first starts. In-rush current can adversely affect the relays on lighting control systems. Therefore, the in-rush capacity of occupant sensor control devices must be evaluated

when selecting ballasts. Fully loaded lighting circuits retrofitted with electronic ballasts can create in-rush currents high enough to weld relay contacts and destroy occupant sensors. Some O.S. have “zero-crossing” circuitry, meaning they do not activate until the current is at the zero point. In-rush current increases as the total harmonic distortion (THD) decreases. Do not specify electronic ballasts with less than 10 percent THD.

TIME DELAY

Failure to set O.S. turn-off time to an appropriate value can be annoying if lights turn on and off frequently or can be a safety hazard when used in rooms that have no windows. Ensure the O.S. has an adequate adjustable time delay (30 seconds to 20 minutes, minimum) for the application. Initially, set delay to a long “on” period, then adjust time delay setting based on occupant movement patterns. Do not use the “instant off” feature in any installation.

SENSOR SPECIFICATIONS

Include the following information when specifying O.S.:

- Sensor Type: passive infrared, ultrasonic, dual-technology, other
- Mounting: ceiling, wall switch replacement, recessed, surface, other
- Coverage Pattern: wide angle, narrow, 360 degree, other
- Lens Type: standard, dense, long range, other (for PIR only)
- Special Environment: high humidity, high or low temperature, other
- Quality/Safety: specify Underwriters Laboratories (UL) listing
- Time Delay: 30 seconds to 20 minutes minimum, adjustable
- Input Voltage: 120V, 277V, other
- Adjustable Frequency: for multiple ultrasonic O.S. in same area only
- Manual Override and Manual on-off

INFORMATION ON PROJECT DRAWINGS

For projects with many sensors and many different sized coverage areas, include occupant sensor schedule and coverage patterns on

drawings. Schedule should include sensor type, description, coverage, and applicable notes. Coverage patterns should be drawn to scale.

NATIONAL ELECTRICAL CODE (NEC) REQUIREMENTS

The 1996 NEC has specific requirements related to the installation of occupant sensors. Section 110-16 states that illumination in electrical equipment rooms "shall not be controlled by automatic means only." Be sure to include manual overrides for O.S. installed in electrical rooms. Section 210-70 permits the control of lighting outlets by O.S. in dwellings as long as there is manual override capability or separate wall switch. See NEC Handbook for details.

OCCUPANT SENSOR ETIQUETTE

Issue memo to personnel and post signs for visitors indicating the presence of O.S. and reminding everyone that lights off does not necessarily mean that the office is closed or that someone is not at work that day.

DAYLIGHTING AND DIMMING COMPATIBILITY

Occupant sensing may be coupled with daylighting sensors to provide further energy savings. For fluorescent lighting control, be sure that compatible dimming ballasts are specified for correct light output adjustment by daylighting sensors. It is preferable for the lamp, dimming ballast, daylighting sensor, and occupant sensor to be "system rated" – that is, designed and certified by their manufacturers to perform effectively together. The E Source electronic encyclopedia has a daylighting design section. The Whole Building Design Guide has a resource page on daylighting.

OCCUPANT SENSORS FOR HVAC CONTROL

Another recent breakthrough has occurred in the control of heating and air conditioning in rooms with individual thermostats. Systems are on the market that incorporate sophisticated occupant sensors combined with door contacts to ensure heating or air conditioning equipment is not operating in unoccupied rooms. They have several levels of temperature setback depending on the length of time the room is unoccupied. They include humidity sensors so

that cooling is provided to control humidity. These systems have been used successfully in Army, Air Force and Navy installations, such as barracks, bachelor quarters, Navy Lodges, and the Armed Forces Recreation Center at Disney World. Conference rooms and classrooms are also good candidates for this energy saving system. They are suitable for retrofit or new construction. Be certain the equipment supplied is designed as a package, not just a bunch of individual components thrown together by a contractor or supplier that don't have proven performance as a system.

HOW TO CHOOSE A QUALITY UNIT

To ensure you or your contractor are installing quality O.S. designed to perform the required functions, be sure the sensor

- is Underwriters Laboratory (UL) listed
- catalog data includes all the information indicated in your sensor specification
- is compatible with the lamps and ballasts used on the project
- is compatible with daylighting and dimming controls, if they are included in the project
- is designed for the environment in which it is to be used

Finally, look for an extended warranty (up to 5 years) as a sign of a quality product backed by a reputable manufacturer

NEW LIGHTING PRODUCTS COMING SOON

- The 30 mm by 28 mm size is emerging as the new standard for both one- and two-lamp ballasts with major European manufacturers. Moving to this size for T8, T5 and 36, 40, and 55 watt twin tube CFL ballasts.
- Some CFL ballasts will double as a lampholder, reducing the wiring in the luminaire and eliminating separate lampholders.
- Ballasts will be available for the full line of T5 lamps. Dimmable ballasts will take at least another year to show up, because lamp specifications were not ready until recently.
- Luminaire manufacturers will offer products that incorporate simple photosensors that connect directly to the ballast.
- By the year 2000, several manufacturers are likely to include a standardized digital port in their dimming ballasts.

- More ballasts with lower total harmonic distortion (THD) and improved power factor are becoming available.
- Dimming electronic ballasts offering daylight and motion detection as well as infrared control.
- Expanded lines of low mercury lamps.
- T5 luminaires to become standard in the U. S.
- New trim luminaire styles for T2 and T5 lamps.
- More fiber optic lighting systems.

REFERENCES AND SOURCES OF ADDITIONAL INFORMATION

1. E SOURCE Electronic Encyclopedia, Chapter 5, Daylighting and Chapter 11, Lighting Controls, E SOURCE, Inc., Boulder, CO, 303-440-8500, www.esource.com

2. The Architect's Guide to Energy Conserving Products and Systems, National Institute of Building Sciences (NIBS) Construction Criteria Base (CCB), Washington, DC, 202-289-7800, www.nibs.org

3. Lighting Handbook, Eighth Edition, Chapter 31, Lighting Controls, Illuminating Engineering Society of North America, New York, NY, 212-248-5000, www.iesna.org

4. National Electrical Code Handbook, Seventh Edition, National Fire Protection Association, Quincy, MA, 800-344-3555, www.nfpa.org

5. Architectural Graphic Standards, Ninth Edition, Chapters 13 & 18, The American Institute of Architects, John Wiley & Sons, Inc., Somerset, NJ, 800-225-5945, www.aia.org

6. Whole Building Design Guide, Passive Solar Industries Council, Washington, DC and Naval Facilities Engineering Command, Atlantic Division, Norfolk, VA. (To be web page and CCB accessible), www.psic.org www.efdlant.navfac.navy.mil/Lantops_15

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